

**UNITED STATES DEPARTMENT OF AGRICULTURE  
NATURAL RESOURCES CONSERVATION SERVICE  
INTERNATIONAL PROGRAMS DIVISION**

**Republic of Congo International Assignment  
Embassy Science Fellow  
David A. Dyer  
Executive Summary**

**Section A.**

The purpose of this assignment was to provide agronomic, soil science and agriculture development assistance, along with technical assistance in soil erosion, watershed protection and conservation planning. An additional purpose was to provide assistance to Congo School Gardens Program which has the goal of improving in-country food security. The assignment took place October 27 to November 24, 2007.

I first met with the Republic of Congo Ministers, NGO's and key scientists who have responsibilities related to the assignment and gave them a briefing on my assignment and proposed activities. I then traveled to many parts of the country to review field conditions related to my assignment and determine recommendations.

Met with Mr. Daniel Owassa, Foreign Affairs Secretary General. He stated the need for agriculture development and supported this assignment.

Met with Mr. Auguste Itoua, Interim Chief of Cabinet of the Ministry of Agriculture. He stated that RoC did not have a national seed plan and it would be beneficial to improve the quality of cultivars used. He stated that there are no soils testing laboratories in RoC and that regional MoA offices could use inexpensive soil testing methods and training. He stated that agriculture science is taught at three levels: Junior School - 14 to 15 year old age group, High School - 15 to 20 year old age group and Rural development Institute which has a 3 to 5 year program. He stated that RoC does have a general soil survey and a few detailed soil surveys; moreover, that there is a need for more detailed soil surveys. He stated that in rural areas land ownership is established from family history of land use and in most cases does not have modern legal deeds. It was discussed that this makes investment in agriculture equipment and facilities difficult.

**Recommendation #1**, Request TDY USDA Soil Scientist to provide training to the Ministry of Agriculture and NGO's in the use of soil fertility testing methods and equipment (attachment #1) at four RoC regions: Cuvette Centrale, Plateaux, Lekoumou and Niari. The soil science training would also include basic soil science concepts, soil erosion control, composting methods, organic agriculture methods, use of soil surveys and methods of soil mapping.

**Recommendation #2**, Encourage a RoC agriculture delegation to travel to the World Ag Expo, Tulare, CA, USA, February 12-14, 2008 (the worlds largest agricultural exposition, 1,600 exhibitors, more than 100,000 attendees) <http://www.worldagexpo.com> to be exposed to new agriculture technology and long term possibilities for RoC agriculture. This would encourage the use of USA agriculture technology, materials and equipment. All hotels within a 50 mile radius are booked and full as the event date gets close. Assistance could be requested from the USDA-NRCS District Conservationist in Modesto, CA, who has worked in Africa and speaks French.

**Recommendation #3**, Request TDY USGS Geologist to determine the potential to re-establish a fertilizer mining industry in RoC, focusing on rock phosphate (apatite) - phosphate(P2O5), potash (potassium oxide - K2O) and calcium (Ca) deposits. (P2O5) was mined near Pointe-Noire by a French company, (K2O) was mined near Makola and (Ca) was mined near Madingo. RoC Oil - naphtha reserves can be utilized for nitrogen fertilizer (anhydrous ammonia) and pesticide production. This will support the RoC long term goals of developing improved agriculture production systems, increasing internal food security, increasing farm income and providing for increased RoC export potential.

**Recommendation #4**, Request TDY USDA Agriculture Economist to analyze and determine the long term RoC agriculture income potential. This will provide information to increase the political support for agriculture development. At this time the agriculture sector is not effectively competing with the oil and logging sectors for political leadership and support.

Met with Mr. Gregoire Moua-Likibi, Chief of Cabinet of the Minister of Environment. He stated that RoC does have erosion problems in forest logging areas and that garbage and waste systems are in poor condition.

Met with Mr. Yoka, Director of the Rural Development Institute (IDR). It was explained how in the USA farmers use resource conservation districts and engage in conservation planning as a bottom up way of dealing with farming problems. He agreed that that is the best way to provide extension assistance. It was agreed that for low income farmers, a small increase in production can yield a large increase in farm income. He stated that RoC did not have enough rice and corn to feed animals and that forage grazing areas were underutilized. He discussed that there was a lack of opportunities when students graduated from agriculture studies.

**Recommendation #5**, Request TDY USDA Rangeland scientist, USDA Veterinary scientist and USDA Sociologist to assist in the expansion of grazing livestock (cattle, goats and sheep) in RoC savanna areas which are now underutilized and could support an additional 3,000,000+ head of livestock. TDY's would provide training in stock water pond lining, water development (water table is at 300 to 500 feet depth), fencing, grazing rotation management, conservation planning, animal health and disease control (also ensuring wildlife disease safety). TDY's would determine land ownership, population movement, micro-credit needs, government policy and social impediments to ensure full utilization of grazing resources (USA Homestead Act could be used as a model). TDY's would locate the best stock to import to re-establish animal herds and

would identify the associated materials that would need to be manufactured in RoC or imported.

Met with Mr. Midou Ibrahima, Country Manager, The World Bank. The Republic of Congo: Agricultural Development and Rural Roads Rehabilitation Project was reviewed and discussed the need for Ministry of Agriculture capacity building before the start of the project. Mr. Ibrahima stated that they will start the project soon and will adjust the capacity building effort on an ongoing basis. He also stated that developing a country wide foundation seed service and soil fertility testing was important.

**Recommendation #6**, Support the World Bank - Republic of Congo: Agriculture Development and Rural Roads Rehabilitation Project to provide coordination with other recommendations and activities related to the project.

Met with Ambassador Robert Weisberg, Joseph M. O'Brien - International Partnership for Human Development and James Conway - USAID to review Brassaville school remodeling program. The U.S. Navy Seabees and other local staff did an outstanding job and the finished school buildings are now fully utilized. The USDA - USAID school lunch program (rice, beans and oil) is being administered with a high level of professionalism; Moreover, U.S. farmers and tax payers would be proud of this effort.

Met with Ken Cameron with the Wildlife Conservation Society field veterinary staff. He advocated the need to keep agriculture animal's disease free, so diseases do not migrate to wildlife. He stated that too many agricultural animals are shipped to RoC with diseases and it would be better for wildlife if RoC developed a livestock industry. Standard extension veterinary services would lower the disease risk. He felt that RoC has an excellent potential for agricultural livestock development. Recommendation #5 supports Mr. Cameron's comments.

Met with USAID Kinshasa DRoC staff, Dr. John Flynn - CARPE and Dr. Ken Wiegand - Livelihoods office and with Dr. Pierre Rosseau - SECID South East Consortium for International Development. They provided information on their efforts to expand the potential of using mosaic virus free cassava cuttings to improve food security in the Congo. As an alternative to using extension services, they use local community groups such as churches. They provide two day training sessions to community groups on the use of cassava and other crops. They have tested and grown 200,000 pounds of foundation seed (beans, corn, maize, rice, peanuts, cow peas, soybeans). Keeping a very narrow focus has allowed them to use \$5,000,000 over a three year period to feed 1,000,000 people per year. Dr. Rosseau suggested he would be willing to transfer small amounts of seed and cuttings to RoC Minister of Agriculture, National Center for Seed Improvement, additional testing and evaluation. Also, they suggested I contact Dr. Kasu Sam, agronomist, in Oyo to review his use of mosaic virus free cassava cuttings.

**Recommendation #7**, Facilitate with Dr. Rosseau the transfer of small amounts of seed and cuttings (the above species) to RoC Minister of Agriculture MoA, National Center for Seed Improvement NCSI for additional testing, evaluation and foundation seed increase. Encourage

MoA - NCSI to provide seed and cuttings to other MoA offices and local community groups, school garden sites and NGO's through out the country.

**Recommendation #8**, Review and emulate for use in RoC (train the trainer) cassava production training methods and program used by Dr. Wiegand to provide two day training sessions to local community groups, church groups and NGO's who work with farmers.

**Recommendation #9**, Utilize the Central Africa Regional Program for the Environment CARPE - USAID web site to keep current on land use pattern changes such as logging in forest areas. <http://carpe.umd.edu>

Met with Joe O'Brien, IPHD and U.S. Embassy staff to review and determine the possible mitigation solutions of three Brassaville flood sites. It was determined that little civil engineering efforts were made when the city was established so flood waters are not captured and diverted in a safe manor. Million's of dollars in civil engineering works would be needed to solve the flooding problem on a long term basis.

**Recommendation #10**, Provide sand bags which could be used to protect homes which flood one to two feet deep on the upper end of the flood gradient. Contact FEMA to determine if they can send pre flood disaster planning and flood disaster response information. Determine if TDY FEMA staff is needed to provide guidance and training to city staff and community groups in Brazzaville and Pointe-Noire.

Met with Dr. Ambende Daniel, Minister of Agriculture, National Center for Seed Improvement, Talangai. He stated that he was interested in obtaining improved seed and cassava cuttings from the agronomists in Kinshasa. They are working with corn, peanut, soybeans, potatoes and cassava. They do have a nematode problem on their farm. The facility was in poor condition with little working equipment; however, they did still perform the function of testing different seed collections and increasing foundation seed. Most farm work is by hand. They did use 200 kilograms per hectare of NPK 15-15-15 fertilizer. They did not have the means to do soil testing and I obtained soil sample #1 for testing at a U.S. laboratory.

Met with Dr. Kasu Sam, Agronomist, NG-Enterprise and kiessi water complex at Oyo. The facility is owned by President - Denis Sassou-Nguesso. Dr. Sam demonstrated how he has promoted the use of mosaic virus free cassava received from agronomists in Kinshasa. The cassava processing plant and the water bottling plant are both built to developed world standards and operate with a high level of efficiency. The cassava plant has large soaking containers which leach out the cyanide, a chipper and a large dryer. The facility also processes cassava leaves. Dr. Sam provided a tour of the Presidents farm where cassava (planted 1 meter X 1 Meter) is being grown in rotation with new NERICA rice. The tour also included a palm oil tree site. They have imported and are using disease resistant NDDAMA cattle. Moreover, the cattle appear very healthy and are being well managed.

Met with the Minister of Agriculture staff at Owando to determine their capacity building needs. The staff noted that they needed training in basic agriculture extension activities such as soil testing and soil

fertility management. I reviewed the potential for using inexpensive soil testing kits and the training requirements (attachment #1). They felt the general soil survey they had was not adequate because it did not provide enough detail. I explained the soil survey process required to produce an order two detailed soil survey. They also stated that they need to have access to new seed cultivars. They also described how there are many soils in the area which are water logged and have poor drainage. It was stated that it would be best to focus on increasing the productivity of the best soils and let the poor drainage soils return to a forest cover. We reviewed the MoA research farm and I obtained soil sample #2 for testing in a USA soil laboratory.

Met with Kevin Sarsok and his staff at International Partnership for Human Development (IPHD), Pointe-Noire to review Riviere Rouge Agriculture Training Center and to review flooding areas. Riviere Rouge Agriculture Training Center has not been used for many years and will benefit from a remodeling effort by IPHD. The facility is well laid out and has adequate areas for both crop and livestock production; Moreover, the facility will make an excellent training center. I obtained soil sample #3 for USA laboratory testing. After heavy rains in Pointe-Noire, Mr. Sarsok and I toured the flooded areas of the city. Recommendation #10 comments are the same for the Pointe-Noire area.

Traveled to Dolisie and Sibiti with Kevin Sarsok to meet with additional IPHD staff and review the Congo School Gardens Program and USDA school lunch feeding programs. Both programs are doing an excellent job and all staff are highly professional. I reviewed the school gardens at Lisiemi, Kikondi, Bihoua and Henri Bounda schools. I obtained soil sample #4 at Lisiemi for USA laboratory testing. I observed that the USDA school lunch feeding program was in effect and was being fully utilized at all schools visited. I discussed with Bernard Tombet IPHD, the development of a Republic of Congo plant list; Moreover, he took the lead in its development.

**Recommendation #11**, Utilize the Republic of Congo Plant List, attachment #3 (file: Plants.xls), for future Congo School Garden Program and agriculture development activities.

**Recommendation #12**, Increase the size and number of composting pits at the school gardens. This will increase organic matter input and fertility to the gardens. Enhance soil fertility by adding materials (wood ash, egg shells, etc.) to the compost pits which will raise soil Ph. Obtain inexpensive soil Ph kits to track and adjust garden soil Ph and teach chemistry.

**Recommendation #13**, Obtain non-hybrid seed for garden use so seed collection, cleaning and storage can be taught.

**Recommendation #14**, Consider expansion of the Congo School Garden Program to the Mindouli area.

Met with Joe O'Brien and his IPHD staff to review the Songhai Agriculture Development Farm at Kombe. The farm is highly utilized and has excellent organic agriculture systems in place. A new well is needed to improve the irrigation potential in the dry season.

**Recommendation #15**, Fund the new well at Songhai for irrigation improvement.

**Additional recommendations:**

**Recommendation #16**, Utilize the 1963 Congo Phytogeographie (vegetation) map for future RoC natural resources and agriculture activities. A field review by me and other Congo staff determined the map to be 90% correct. Some forest areas have been converted to savanna; however, many forest areas which have been logged are allowed to return to forest cover. This map and other Congo topographic, soil, geology and hydrographic maps are located at the European Digital Archive on Soil Maps of the World (EuDASM)

[http://eusoils.jrc.it/esdb\\_archive/EuDASM/EUDASM.htm](http://eusoils.jrc.it/esdb_archive/EuDASM/EUDASM.htm)

**Recommendation #17**, Utilize the laboratory results from the five soil sample tests to improve the understanding of RoC soil fertility issues and assist with RoC capacity building.

**Recommendation #18**, Encourage the Minister of Agriculture and NGO's to promote the use of erosion control methods such as multi-story cropping and residue and tillage management with the goal of maintaining soil cover. It was observed that farming on high erosion slopes greater than 15% is taking place to a moderate extent. All logging areas are in need of soil erosion conservation practices.

**Recommendation #19**, Encourage the Minister of Agriculture and NGO's to utilize and consider testing the plants listed in attachment #2, Reference Review. Consider translating this report to French.

**Summary:**

The Republic of Congo has a great potential in regards to agriculture development. The natural resource base can support a large increase in food production. RoC has ample water supplies for dry season irrigation, a good climate, in country fertilizer resources and soils which can be managed for optimum output. There is a need to aggressively promote private sector credit, fertilizer and seed supply and distribution; moreover, ensuring that government is assisting rather than inhibiting the private sector. There is a great opportunity in RoC to promote rural growth which will greatly reduce poverty. Roads and railways are targeted for improvement which will allow faster rural growth and modernized agriculture methods to be utilized. Agriculture research and extension needs to be expanded and narrow effective priorities established.

**Section B.**

The people who participated are:

Kevin Sarsok and IPHD Staff  
International Partnership for Human Development  
Pointe-Noire, RoC

Joseph O'Brien and IPHD Staff  
International Partnership for Human Development  
Brazzaville, RoC

Mr. Daniel Owassa  
Foreign Affairs Secretary General  
Mr. Auguste Itoua  
Interim Chief of Cabinet of the Ministry of Agriculture  
Brazzaville, RoC

Mr. Gregoire Moua-Likibi  
Chief of Cabinet of the Minister of Environment  
Brazzaville, RoC

Mr. Yoka  
Director of the Rural Development Institute  
Brazzaville, RoC

Mr. Midou Ibrahima  
Country Manager  
World Bank  
Brazzaville, RoC

U.S. Ambassador Robert Weisberg and Staff  
Brazzaville, RoC

Ken Cameron  
Wildlife Conservation Society Field Veterinary Staff  
Brazzaville, RoC

Dr. John Flynn  
Dr. James Conway  
Dr. Ken Wiegrand  
USAID  
Kinshasa, Democratic Republic of Congo

Dr. Pierre Rosseau  
South-East Consortium for International Development  
Kinshasa, DRoC

Mr. Daniel Ambende  
Minister of Agriculture, National Center for Seed Improvement  
Talangai, RoC

Dr. Kasu Sam  
NG-Enterprise and Kiessi Water  
Oyo, RoC

### **Section C.**

The benefits of this project are an improvement in natural resources management and agriculture which will improve farm income and reduce poverty in Republic of Congo. The promotion of USA agriculture technology, materials and equipment will benefit both the Roc and USA agriculture sector.

## Section D.

A power point presentation will be developed and this report will be given to other specialists. A remote power point presentation will be given to Washington D.C. staff.

### **Attachment #1, Recommended Soil Testing Equipment, Phase 1**

The following items are easy to use in the laboratory or in the field and form a foundation for soil testing and soil fertility management. Recommend one set for each location being trained.

One vender could be Spectrum, phone number, 800-248-8873,  
[www.specmeters.com](http://www.specmeters.com)

1. Multi-function pH/EC meter D-24 item 2172	1 ea	\$1,100.
2. Cardy nitrate NO3 meter, 2300	1 ea	1,300.
Soil nitrate kit 2329	1 ea	50.
Sampling sheets 2135	1 ea	40.
Hand plant sap press	1 ea	20.
Hydraulic plant sap press 2720	1 ea	400.
3. Cardy potassium K+ meter 2400	1 ea	400.
Soil K+ kit 2434	1 ea	50.
4. Standards, 2338, 2339, 2414, 2418	4 ea \$20.	80.
5. Extra Batteries		100.
6. Phosphorus liquid test kit		100.
Total		\$3,640.

### **Attachment #2, Reference Review, Republic of Congo**

Two thirds of the work force is working in agriculture, yet the agriculture in the country is undeveloped and not profitable. Less than 2% of the land is cultivated; the crops established are manioc, sugar, rice, corn, peanuts, vegetables, coffee, cocoa, palm oil and forest products. Agriculture is mainly based on extensive rotation of cleared forest spaces cultivation, abandonment, fallow re-forestation and subsequent re-clearing.

#### **Climate**

Republic of Congo is divided in half by the equator. The tropical jungle to the North has a dry season in January and February, with high rains in June. The relative humidity stays consistently in the high 80s. The southern Republic of Congo has a rainy season November to April and a dry season June to October. It is slightly cooler June through august by about 3 degrees C on average. The Relative humidity stays constant in the low 80s. The highest elevation is 903 meters at Mount Berongou.

Along with the tropical forests there are coastal plains, fertile valleys, central plateau and forested flood plains. Nearly two-thirds of the country is covered with tropical rainforest of African oak, red cedar, walnut, softwood okoume, and hardwood limba. The coast and swampy areas contain coconut palms, mangrove forests and tall grasses and reeds.

[www.africanconservation.com/congoprofile.html](http://www.africanconservation.com/congoprofile.html)

## Soil

Central Africa is characterized by infertile, acid Utisols, Oxisols and Entisols in both forested and savannah regions. Vertisols are the most abundant grassland soils in humid tropical areas. Slash and burn agriculture is the most common form of agriculture in most of the area. Areas of forest are cleared or burned and crops are raised for a period of two to three years then allowed to convert back to forest trees for 10-20 years while other patches are farmed. This system works well when population pressure is low and rejuvenation period can be longer. Soils are commonly classified as Oxisols or Ultisols. The two common tools for tillage in equatorial Africa is the village made hoe, does not disturb the soil enough to cause major erosion issue, and the disk plow, which does increase erosion problem. (pg 609#7)

- Many tropical soils are potentially unstable, low in fertility, easily eroded and shallow( pg 1 # 10 )
- Western Africa is a humid, forested area and dominant soils are high in plinthite and ironstone ( pg 602 # 7)
- Plinthite forms on iron-rich soil layers that are saturated with water part of the year. ( pg 602 # 7)
- It is rocklike and almost a waterproof material (pg 602 #7)
- The few inches up to three or four feet of soil above the solid becomes saturated and is easily eroded during heavy rains (pg 602 #7)
- A cause of productive loss in tropical regions is the irreversible dehydration of hydroxious ion oxides. When forest cover is removed for extended periods of time, temperature and moisture regimes change of the soil and plinthite in the soil hardens into ironstone pebbles or an ironstone layer that reduces or prevents water or root penetration and allows for soil above the ironstone to be washed away (pg 42 #7)
- At this time fertilizers are not added to this land, fertilizers are high priced and hard to come by, many nitrogen fertilizers cause soil acidification and liming materials are scarce. ( pg 42 #7)
- Although tropical forests produce great quantity of vegetation they are often established on unfertile soils high in aluminum or iron. (# 11 pg 305)The forests are able to exist due to their self replenishing nature, leaves and twigs drop to decompose and feed the tree. (#11 pg 306) If these trees are taken from the soils, the soils turn to their infertile characteristics. Keeping trees incorporated into tropical agriculture is greatly important if fertility is to be retained.

Soil Classification: A Global Desk Reference pg 32

- oxisols- low weather able mineral content in the sand fraction, low permanent charge and proportionately high pH- dependent charge, yellowish to reddish colors and deep zones of alteration.
- entisols- evidence of soil forming material not erased by soil forming processes, or only ochric epipedon present as evidence of soil formation.

- inceptisols- weak subsurface structure development or evidence of alteration and hydrolysis to release iron resulting in some reddening of soil material.

#### Soil Genesis and Classification

- Oxisols pg 331
  - Most nutrients come from dead plant tissue or are within living plant tissue, due to the very low nutrient reserve in weathering minerals and the low CEC of the soils.
  - Shifting cultivation and limited grazing are the common practices for native cultures.
  - Contents of exchangeable Ca, K, and Mg as well as contents of extractable phosphorous, zinc, copper, and manganese significantly increase in the surface horizon as the density and size of vegetation increase.
  - They have low water holding capacity, very low nutrient reserve, and high permeability.
  - Non-sandy mineral soils containing few weathering minerals and low cation exchange capacity.
- Entisols pg 273
  - **H**ave little or no evidence of development of pedogenic horizons.
  - Erosion by water, wind, and mass wasting is important in steep and hilly mountainous areas.
  - Psamments have textures of loamy fine sand or coarser and are better drained than Aquents.
- Inceptisols pg. 309
  - Profile features more weakly expressed than those of many other soils and retain close resemblance to their parent material.
  - Many inceptisols are on steeply sloping terrain.
  - Aquepts have redoximorphic features and are saturated with water at some period of the year unless they are artificially drained.

#### Goodes World Atlas

- Made up of Hills and Low table lands and plains by the sea
- Line formed by Mossendjo and Djambala that separates southern and northern Congo
  - South- coast and Brazzaville receives 100-150 cm annual precipitation.
  - North- 150-200 cm annual precipitation.
  - With its top edge at the equator, on the east side there is a small patch of 100-150 cm per year area.
- Congo is separated into tropical rainforest (broadleaf evergreen trees) and areas of grass and other herbaceous plants with broadleaf deciduous trees.
- Majority of Congo (not the coast) is 1000-2000 ft (305-610 meters) some patches of higher.

#### **Farming Practices**

Agricultural land in most tropic and sub-tropic areas is dominated by low activity clay. (pg 67 # 5) These soils are less suitable for conventional mechanized and high-chemical input farming methods. These soils often have low fertility and are highly erodable if left unprotected. Knowledge of alley cropping and agroforestry is scarce and often overlooked if a farmer is in a desperate situation. Often farmers will purposefully slope the land to erode old soil and

regenerate the new soil below. Instead, it is important that live or dead mulches are used to suppress runoff. (#5 pg 65)

- Shifting cultivation on forested soils generally means partially clearing or burning a patch in a forest, raising crops mainly by hoe culture and to a lesser extent by animal power, and then allowing the patch to revert to forest after 2-3 years the patch is left in forest until the farmer needs it- 10-20 yrs. As population pressure increases the fallow/forested period becomes shorter. When steeply sloping land is burned and cleared it is very susceptible to erosion, (#7 pg 601).
- Soil surface covered is formed by living and dead mulches including herbaceous plants and perennial cover crops, crop residues, and tree litter and pruning's can effectively check raindrop impact and runoff. This cover approach is more effective than a barrier approach, (pg 129 #9).
- Intercropping is used by many farmers as an insurance that there will be some yield, (pg 116 #10 ).

### Vegetation

- Agroforestry is an integration of a tree component into an agricultural production, trees are very important in the tropics. Hedgerows can be oriented to minimize shading of ground crops between the rows, and trees should be pruned for the same reasons. All pruning's should be incorporated into the soil or used as green mulch, (# 5 pg 69).
- Leguminous trees can be used as a shade cover for perennial crops. Leguminous trees are rapid growers and can out-compete competitors. They are adaptable to a wide range of soils including those that are low in nutrients. *Acrocarpus fraxinifolius* has been grown in Nigeria and Zambia successfully as one of the fastest growing legume trees, ( #1 pg 193).

### Developing an Agriculture System

- Agricultural production must start with the small resource-poor farmers, but to enable them to participate in sustainable soil and water management, practices must be easy and adoptable, (pg 29 #8).
- Poverty and malnutrition dictate the need to seize short term profit even at the expense of long term resources, (pg 114 #8).
- Systems need to be developed that make the most efficient use of available internal resources on the farm, ( pg 204 #5).
- Farmer involvement with research will interest not only the farmer but lead to spread of the knowledge to neighbors, ( pg 204 #5).
- Crops need to be diverse. Farmers need to have the ability to be flexible with the market and have crops with multiple purposes, ( pg 204 #5).
- On steep slopes and in semiarid land where plowing is not practicable, tree crops can often yield valuable harvest.
- Women do most of the food farming in Africa but have little access to the means necessary, (pg 220 #6). Women farmers are being ignored through Africa because development planning still fails to include women, (pg 220 #6).

## **Neem Tree**

- The Neem tree is a member of the Mahogany family, (#3 pg 23). It remains in leaf except in severe drought. Though native to the Indian subcontinent, it has been introduced to Africa and seems to do well. It is an easily propagated tree, both sexually and vegetative. The tree grows best in areas of rainfall between 400-1200 mm, (#3 pg 26). It thrives under hot conditions and does not stand up to cold or freezing temperatures. It grows well on some acid soils, it is said that the tree's leaves are alkaline and when they fall they help to neutralize the soil. It can not stand waterlogged soil and will die if a site is waterlogged. It is well known for its great growing on dry infertile sites and does better than most trees on shallow hard panned soils. The Neem tree has pesticide properties that can be extracted and used as a pesticide in many third world countries, (#3 pg 31).

## **Vetiver Grass**

- Vetiver grass is native to low; damp sites such as swamps and bogs, but grows well on hillsides, (#12 pg 71). There are two types of vetiver grass; the "domesticated" type from South India is the one that is distributed through the tropics. The wild type from North India could become a weed problem if it is used. A plant is insensitive to photoperiod and grows year-round if temperatures permit. It does not establish well under shady conditions but once established will tolerate near darkness under rubber trees and tropical forests, (#12 pg 73). Vetiver has a deep and extensive root system. Moisture requirements vary from 200 – 5000 mm and plants have been known to grow in all ranges. It is propagated by root cuttings and requires very little maintenance. However, cutting the tops produces more tillering and a denser hedge.

## **African Yam Bean- Tropical Legumes- (pg 27 #1)**

- Produces small tubers below ground that look like elongated sweet potatoes.
- Contain more than twice the protein of a sweet potato or Irish potato.
- Above ground produces good yields of edible seeds.
- Vigorous vine that climbs over 3 m (can be supported by trees in intercropping system).
- Pretty for ornamental uses.
- Found growing wild through much of tropical Africa.
- Seems little affected by altitude, elevations from sea level to 1800 m., ( good for all of Republic of Congo)
- Grows well on acidic soils, and highly leached sandy soils of the humid lowland tropics.
- Slow to set seed- but after it does it will continue year round.
- Tuber yields vary between cultivars- some produce none others up to .5 kg per plant
- Propagated by either seed or tuber.
- Humid tropical climate with well drained soil.
- Grows on supports ( could use living supports of leguminous tree)
- Tubers take 5-8 months to mature to a size that is good for harvest.
- An unidentified yellow mosaic virus that attacks the plant has been observed at the International Institute of Tropical Agriculture, Nigeria.
- Fungal diseases can be a problem and also susceptible to nematode damage. NOTE: Neem tree can be used to protect against some nematodes ( pg 51 #3) and also has some antifungal properties, ( pg 53 #3).

- Little is known of the natural varietal differences.

#### Contacts

Department of Crop Science, University of Nigeria Nsukka, Anambra, Nigeria  
International Grain Legume Information Centre, International Institute of Tropical Agriculture. PMB 5320, Ibadan, Nigeria

#### Cocoa (Theobroma cacao) (pg. 163 #2)

- Native species of tropical humid forests in South America.
- Grown in Ivory Coast, Nigeria, and Cameroon, (pg 166 #2).
- Has a tap root that extends to 150 cm if conditions are right.
- Feeding roots emerge laterally.
- The bulk of feeding roots are concentrated to the surface, so disturbing the soil will be harmful.
- Optimum growth range temperature is between 15 and 32 degrees Celsius.
- The absolute minimum for any length of time is 10 degrees Celsius.
- Values of rainfall lower than 1500 mm may mean irrigation is necessary.
- Values beyond 3000mm may mean excessive rain and favor disease.
- Rain distribution is very important and 10 cm a month is good distribution.
- Very coarse soils are not generally used.

#### Pollination

- Many of the homozygous types such as West African Amelonados, are self incompatible.
- Natural pollination occurs only with the help of small crawling insects.
- Ceratopogonid midges are the most important pollinating insect for cocoa.
- Ants are also pollinators along with the wind occasionally.
- Most pollination occurs early in the day.
- A special feature of cocoa is self incompatibility shown by some cocoa types.

#### Seeds

- Self compatible have advantage in better fruit set under varied conditions.
- Self incompatible are important in commercial hybrid seed production.
- Seed propagation is the cheap easy way but it will give too much variation.
- Seeds are non-dormant and lose viability quickly within 7 days of extraction.
- If stored more than 7 days seed needs to be stored in moist charcoal and packed in polyethylene bags. The best method is to store as pods.

#### Planting and maintenance, (pg 183 #2).

- Since cocoa is cross pollinated it is not advisable to import germplasm as pods or seed.

Vegetative materials such as bud wood can be imported, which is then budded onto stock plants to get true to type plants.

- The potting medium of farmyard manure, sand and soil in equal proportions is good enough to raise seedlings.
- Seeds will germinate any time of the year.
- Seeds are to be sown with the hilum end facing down or sown flat.
- Depth should be just enough to cover the seeds with soil.
- Removal of pulp with abrasion has been seen to be an advantage for percent germination.
- Seed will germinate in about a week's time.
- Four to six month old seedlings are suitable for planting.
- Budding on rootstocks of about 6-12 months growth is most often done, but can be done on 2-4 months.
- Rooting cuttings- cuttings should be taken from fan branches though chupons can be used spacing is generally low in the insitu system of planting in Africa.

- For the Amelondado cocoa a close spacing of 1.7x1.7m to 2.7x2.7m was the optimum.
- Pruning is done to restrict the growth of the plant to a convenient height. (pg 190).
- Pests: Red borer, tea mosquito ( *helopeltis antonii*), Mealybugs ( *Planococcus liacinus*), gray weevil ( *Mylocerus sp.*), cockchafer beetle (*Leucopholis spp.*), citrus aphid (*Toxoptera aurantii*), red branched thrips.
- Diseases are witches broom, coca swollen shoot virus (CSSV), vascular streak dieback and black pod (pg 178 #2)

#### Harvest

- Pods mature about 150 – 170 days from the day of pollination.
- Pods that are green when immature turn yellow when mature.
- Reddish pods turn yellow or orange.
- Pods may remain up to one month on the tree without damages.
- Best to harvest at fortnight intervals or closer if pests are a problem.
- Fruit are borne on the cushions so to avoid damage to the flower cushions harvesting is done with a knife.
- Harvested pods can be stored for 2-5 days. This enhances pre-fermentation activity within the pods.
- Harvested pods are broken by hitting against a hardened surface. Beans are extracted without placenta and are kept for fermentation immediately, pg 208.
- Raw coca beans are covered with sugary mucilaginous pulp and the beans with the pulp around them are called wet beans.
- Fermentation involves keeping together a reasonably wet mass of beans for a period of 4-6 days, pg 209.

#### Contacts

- Institut de Forests, Department Café Cacao. 1827, Abidjan 01, Cote d'Ivoire
- Centre de Co-operation Internationale en Recherches Agronomiques pour le développement BP. 5035, 34032, Montpellier Cedex, France
- Cocoa Research Institute of Ghana. PO Box 8, New Tafo Akim, Ghana
- Cocoa Research Institute of Nigeria. PMB 5244, Ibadan, Nigeria

#### Coffee (pg 295 #2)

- Coffee belongs to the family Rubiaceae, genus *Coffea*. The genus is organized into three sections, *Mascarocoffea*, *Eucoffea* and *Paracoffea*- the first two are natives of Africa, the latter to East Asia.
- Most known coffee species are *Mascarocoffea* or *paracoffea*.
- *Paracoffea* is divided into 5 subsections: *Nanocoffea*, *Pachycoffea*, *Erythrocoffea*, *Melanocoffea*, and *Mozambicoffea*.
- The cultivated species *C. canephora* and *C. Arabica* belong to the subsection *Erythrocoffea*.
- Africa is considered the home of most coffee species.
- *Arabica* and *robusta* (*C. canephora*) coffee produce yields 2-3 years after planting with a life beyond 30 years.
- *C. Arabica* prefers temperatures of 15-24 degrees C and *C. canephora* prefers warmer conditions of 24-30 degree C ( *C. canephora* would most likely be best suited to RoC due to its warmer temperature requirements)
- Requires an average rainfall of 1800mm per annum.
- *Arabica* does well in tropical zones if it is at an altitude of 1200- 1800m above sea level.
- Ideal soils are light, deep, well drained, loamy, slightly acidic and rich in humus and exchangeable bases, especially potassium, (pg 307).

- Raised from seed or cuttings.
- They are ready to be planted in the field after 12-18 months.
- Planting holes can be dug three months before planting to minimize soil borne illness.
- Refilled one month before planting with top soil mixed with organic manure.
- Common spacing for traditional tall cultivars is 2.74x1.37m and 1.37x1.37m.
- Compact cultivars 2x2m and 2x1.5m.
- Weeds can reduce coffee yields by 50%+ as well as quality.
- Common methods for weed control are using forked hoes, slashing, mulching and herbicides, (pg 311).
- Use of live mulches can be useful – Desmodium spp.
- Pruning will remove unwanted branches and dead branches.
- Can be mechanically harvested but this requires flat terrain and the trees to be in hedgerows.
- Mainly grown as a mono-crop , but does not have to be.
- In Costa Rica, trees grown with coffee- Cordia spp., Grevillea robusta, Albizia spp., leucaena leucocephala, and cypress spp.

NOTE: leucaena leucocephala is a leguminous tree that can also be used to provide support to a vine crop, (pg 302 #1). Costa Rica coffee and trees grow together. Leguminous Erythrina poeppigiana (grows in Africa and has bright orange flowers (pg 258 #1)) shades the coffee. Above this tree and the coffee is Cordia alliodora which is used for fine furniture making and houses.

- Diseases- categorized as foliage diseases, berry diseases, dieback diseases, trunk and branch diseases wilt diseases and root diseases.
- Pests: Coffee Berry Borer, Antestia bug, scales and mealybugs, coffee leaf miner, stem and branch feeders.

Harvester Manufacturers

- Jacto

<http://www.jacto.com.br/english.html>

KOKINHA

Mechanical coffee harvester: tractor-driven

- Hitch: tractor three-point system
- Hydraulic system: for height and level adjustment
- Harvest system: one side of the tree per pass
- Harvest height: 2.75 meters

Oil reservoir of the circuit: 90 liters

Oxbo

<http://www.oxbocorp.com/history.html>

Oxbo International Corp. develops, manufactures and supplies specialized agricultural equipment for niche market agribusiness worldwide.

**Tropical Lima Bean** (pg 97 #1)

- well adapted to lowland tropics with poor soils.
- Harvest can be made within 5 months of planting but growing conditions can cause this to vary from 3-9 months.
- Harvested just as green color of pod begins to fade.
- Sheds lots of leaves to decay and help soil fertility.
- Can be used as a green manure or as a cover crop.
- Has been grown successfully at elevations up to 2400 m, (good for all of Republic of Congo)

- Prefers well drained, well aerated, neutral soil pH 6-7.
- Must be supported, ( can be supported by trees/natural support that are used as shading and intercropping in a cocoa or coffee crop).

#### Contacts

- Chaire de Phytotechnic des Regions Chaudes, Faculte des Sciences Agronomique de L'Etat, Gembloux , Belgium
- E.V. Doku, Crop Science Department University of Ghana, Legon, Ghana
- International Grain Legume Information Centre, International Institute of Tropical Agriculture, PMB 5230, Ibadan, Nigeria
- CL Tucker, Department of Agronomy and Range Sciences , University of California Davis

### **African Horned Melon**

- Native to Africa.
- Vine grows 5-10 ft long.
- Oblong fruit, 2-4 inches long.
- Fruit is light green when immature and it turns bright orange at maturity.
- Has bland citrus or banana taste.
- Can be strained for juice.
- Marketed as a garnish.
- Sensitive to cold, hot dry prevents powdery mildew.
- Has a weedy nature.

### **Tea (pg 399 #2)**

#### Growing conditions

- Adapts too many growing conditions from sea level to 2600 meters.
- Well drained acidic soils are optimal, pH 4.5-5.5.
- Temperature from --8 degrees C to 35 degrees C.
- Rainfall <700 to >5000 mm.
- Optimal growth usually comes from regions of 23-30 degrees C and annual rainfall of 2500-3000mm.
- Uniform rainfall throughout the year gives the best results (minimum 100-150 mm per month) (Northern Congo may be the best).
- Stressed conditions create chemicals in the tea that cause certain tastes that are known as seasonal quality in manufactured teas.
- Shade trees are grown in tree fields for optimum productivity.

#### Soil and fertility (pg 463 #2)

- Soils that tea is grown on is usually poor in nutrients therefore fertilization makes up about 8-12% of the total cost of tea production.
- Relatively large amounts of N are removed with the harvested shoots and need to be replaced frequently.

NOTE: Incorporating a leguminous tree into the tea plantings could prove to be beneficial, not only would it aid in adding nitrogen and beneficial substance to the soil it would also increase productivity by offering the plants the needed shade.

- Tea has been grown with rubber and coffee and legumes and fruit crops, (pg 491 # 2).

#### Pruning and Plucking

- Periodic pruning of mature foliage is the way to deter a tea plant from becoming a tree, (pg 465 #2).
- Pruning is done by mechanical or manual means.
- Pruning styles are: low (clean or hard), high (cut across or light), lung (one or two leafy branches are left for photosynthetic support).

- Pruning should not be done just before an onset of dry weather, ( sap flow is needed to heal wounds).
- A rest (cessation of plucking) should occur 2-3 months prior to pruning to build up starch reserves.
- Pruning is done every two years at sea level and it increases in years with elevation (In Sri Lanka- low country is pruned every 2-3 years and every 4-5 years in the high country)
- In the tropics plucking is done at intervals of 4 – 10 days.
- The tops of bushes can be trained by the plucking process to a level “plucking table” (for manual picking) or to a dome shape (usually for mechanized plucking).
- Mechanical plucking usually requires flat land and tea of higher quality is hand plucked.

#### Reproduction

- Only bushes with decreased vigor will flower and produce seeds.
- A plant can be allowed to grow into the tree phase and then flower.
- Tea is a highly self sterile plant and cross fertilization is necessary for seed production, ( pg 135 #4).
- Due to its heavy and sticky nature tea pollen is not carried by the wind but by wasps and bees, (pg 135 #4).
- Both stem cuttings and seed propagules are raised under shade.
- Seedlings raised in sand beds or boxes.
- Transfer seedlings or cuttings to polyethylene bags filled with nematode free soil.
- Following rooting (in 6-18 months) the bags are placed in planting holes in the field.
- Older seedling tea can be planted from 3000 to 14000 plants per hectare; for VP tea 12500 to 18000.
- Generally ready for plucking in about five years.
- Mother bushes are used for cutting collections even though cuttings can be taken at all times of the year.

#### Harvester Manufacturers

Ignition Products (India) Pvt. Ltd.

[http://www.ignitionproducts.in/F9471/tea\\_harvesters.html](http://www.ignitionproducts.in/F9471/tea_harvesters.html)

##### Microlite Tea Harvesters (Single Person Held)

Microlite tea harvester is a motor driven high performance powered machine. Run by automotive batteries, this machine is designed in such a way that even the women pluckers can carry it. The machine is highly suitable for even steep terrains. The battery chargers are provided for constant usage of machines.

##### Two Person Tea Harvesters

We design and manufacture two person tea harvesters. It is a mechanized tea harvester that cuts tea leaves by reciprocating blades. Two men operate this machine. It helps in maintaining the level of tea bushes facilitating in uniform growth. The harvested tea is collected into a bag hooked to the machine resulting in very high per cut output. This is powered by 1.8H.P two stroke I.C engine.



[http://www.willames.com/tea/w\\_tea.asp](http://www.willames.com/tea/w_tea.asp)

Tea Harvesters

The patented T1000 "magic carpet" tea harvester presents a revolutionary concept in the mechanical harvesting of tea. Instead of the harvester running on

wheels or tracks, or being carried by workers, it runs on top of the tea bushes. Manufactured from aerospace materials with a very high strength to weight ratio the T1000 is light enough not to damage the bushes while strong enough to be able to perform reliably in arduous conditions in tea estates of all sizes.

**Contacts:**

Tea Research Foundation (Central Africa)

Address: PO Box S 1, Mulanje, Malawi

Telephone: 462 261; 462 271

Activities: Promotion of tea research in the central and southern Africa regions.

Field trials in Zimbabwe and South Africa. Breeding for high quality clones,

efficient fertilizer use, response of bush to mechanization, pesticide residue

monitoring, modernizing manufacture

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**Lablab Bean (pg 59 #1)**

- Already widespread throughout the tropics.
- Many uses.
- Food: young pods are used as table vegetable, leaves and flowers are cooked and eaten like flowers, protein concentrate can be made from the seeds.
- Forage: grazed by cattle, sheep, goats and pigs.
- Effective as a green manure and erosion control
- Good cover crop in coffee and fruit orchards.
- Precipitation 200-2500mm of annual precipitation.
- Humid forests where mean summer temp ranges from 22-35 Celsius.
- Grows in lowlands and highlands- up to 2100m.
- Many soil types are suitable- even poor soils and aluminous soils.
- More resistant to root rot than common cowpea.
- Root knot nematodes affect the crop greatly.

NOTE: certain limonoid fractions extracted from neem kernels are proving active against root-knot nematodes by inhibiting the larvae from emerging and the eggs from hatching, (pg 51 #3).

**Contacts:**

-Tamil Nadu Agricultural University, Coimbatore 641 003, India

-National Bureau of Plant Genetic Resources, Indian Agriculture Research Institute Campus, New Delhi 110012, India

### **Albizia Species** (pg171 #1)

- Has been planted as a shade cover for coffee, cocoa and tea.
- Also aids in developing Nitrogen in soil by litter fall and fixation.
- Extensive root system helps to break up soil pan and aid in drainage.
- The open spreading canopy ideally suits it for agroforestry.
- Trunk exudes gum if damaged and tannins and gums from trees have found commercial use from time to time.
- Fast growing.
- Albizia falcataria is one of the fastest growing trees In the world- native to Asia

#### **Albizia lebbek**

- Albizia lebbek native to tropical Africa
- A. lebbek can be grown on problem soils and on sands near the sea.
- Used as cover crop.
- Can be raised easily from seedlings.
- Promising for fuel forests.
- Good for furniture and the burr is especially prized, ( 178 #1).

#### **CONTACTS:**

Chief Forest Officer, Afforestation Division, Hathi Sar, Naxal, Kathmandu, Nepal  
Western Africa- Projects Department, The World Bank A203, 1818 H Street NW  
Washington, DC 20433 USA

### **Cassava**

-Steven A. Sargent, Horticultural Sciences Department, University of Florida,  
Gainesville, FL

-Scientific Name and Introduction: Cassava (*Manihot esculenta* Crantz) is a woody perennial shrub of the Euphorbiaceae family, and is native to the Amazon region and Central America. It is widely grown throughout the tropics for the starchy root. Cassava is known as yuca (in Spanish), mandioca (in Portuguese), cassave (in Haitian Creole) and manioc (in French). It is consumed in a wide variety of forms, but only after some form of processing. Cultivars are classified into two groups based on the amounts of hydrogen cyanide present. "Sweet types" contain  $< 50 \text{ mg kg}^{-1}$  HCN (fresh weight) and are generally sold as fresh roots, whereas "bitter types" have higher amounts of HCN, but have higher yields and starch content. These latter types are processed into products including flour (from coarse to fine textured), tapioca starch and fermented starch. It is adapted to semi-arid climates and has been a traditional crop for subsistence farmers, although it is increasingly cultivated as an agronomic crop.

-Quality Characteristics and Criteria: Fresh cassava roots are highly perishable under ambient conditions, becoming unmarketable in 3 days or less. However, with proper handling, fresh roots can be stored up to 30 days, permitting export by marine container. The roots should be firm, turgid, fairly straight, and free from mechanical injury, decay, and vascular streaking. The pulp of most common cultivars varies from white to light yellow. Principle causes for loss are vascular streaking, and decay. Extended storage can have two adverse effects on quality: starches are converted to sugars and roots become fibrous, lengthening cooking time (Booth et al., 1976).

-Horticultural Maturity Indices: Harvest maturity is based on the root size desired by the market, and ranges from 6 to 18 mo after planting of the stem sections. Sweet types usually grow faster than the bitter types. The main stem is often trimmed to approximately 1 m (39 in) in height a few days before harvest. Plants are manually pulled, or the root zone mechanically undercut to facilitate plant removal, and individual roots cut. Cassava roots are turgid at harvest and must be handled carefully to avoid splitting the periderm.

-Grades, Sizes and Packaging: There are no U.S. Grade Standards for cassava. However, shippers should consult with buyers to define quality expectations. For example, root lengths in excess of 30 cm (11.8 in) are undesirable to many importers. Commercially, roots are cleaned by brushing, rinsed in water, surface-dried, and coated with paraffin wax prior to packing in corrugated cartons.

-Pre-cooling Conditions: Room cooling is generally sufficient, provided the roots are not held too long at ambient temperatures prior to or after packing.

-Optimum Storage Conditions: Cassava is very sensitive to water loss, and methods used to maintain high RH during storage include moist sawdust and plastic films (Booth, 1976). Paraffin wax is applied to roots exported to the U.S. Waxing and holding at 0 to 5 °C (32 to 41 °F) extends shipping time to > 30 days with minimal occurrence of vascular streaking. A water-based carnauba wax maintained postharvest quality equivalent to paraffin wax.

- Controlled Atmosphere (CA): No commercial-scale recommendations have been reported.

-Retail Outlet Display Considerations: Cassava is normally displayed in bulk and should be held in refrigerated display cases.

-Chilling Sensitivity: Cassava is chilling sensitive, but it can be stored at 0 to 5 °C (32 to 41 °F) with minimal symptom development.

-Physiological Disorders: Vascular streaking appears as blue or purple spots when the root is cut transversely and is a result of an oxidative process in the vascular bundles. It typically develops at wound sites, such as the apical end where the root is cut at harvest, or under breaks in the peel that can occur during careless handling.

-Postharvest Pathology: There are two major postharvest fungal diseases of cassava. Botryodiplodia rot (*Botryodiplodia theobromae* Pat.) invades the pulp beneath the skin, initially developing white mold that later becomes dark grey (Snowdon, 1992). Fusarium rot (*Fusarium solani*, Mart., Sacc.) also grows on the pulp, causing a brown discoloration. Other pathogens reported by Snowdon (1992) include: Aspergillus rot (*Aspergillus flavus*), bacterial soft rot (*Erwinia caratovora* ssp. *caratovora*), Mucor rot (*Mucor hiemalis*), Phytophthora rot (*Phytophthora cryptogea*), Rhizopus rot (*Rhizopus oryzae*), Sclerotium rot (*Corticium rolfsii*), and Trichoderma rot (*Trichoderma harzianum* Rifai).

Quarantine Issues: There are no restrictions on imports from major the production areas.

Suitability as Fresh-cut Product: There is potential for pre-peeled intact or sliced roots, but shelf-life is currently limited to 2 or 3 days under ideal storage conditions due to vascular streaking.

## **Banana and Plantain**

-Scientific Name and Introduction: *Musa acuminata* and *Musa balbisiana*, most cultivars of edible bananas and plantains derive from these two members of the family *Musaceae*. Before the 1940's the cultivar 'Gros Michel' dominated the international banana trade, until it succumbed to *Fusarium* wilt (Panama disease). Since the 1940's the trade has adopted cultivars of the Cavendish subgroup. Bananas are eaten mainly raw as a dessert fruit because they are sweet when ripe. Plantains, also referred to as 'cooking' bananas, are much starchier and can be eaten either ripe or unripe. The edible cultivars of bananas and plantains are seedless. The two obvious tissues that constitute the fruit are the pulp and the peel. The peel is the ovary wall. The pulp originates from cell division of the innermost layers of the pericarp. The growth of the peel begins to slow down as the fruit matures but the growth of the pulp continues, consequently peel splitting often occurs in very mature green fruit.

-Quality Characteristics and Criteria: A premium quality banana is very clean (free from defects such as scars, physical damage, insect injury, and latex staining), free from decay, has an adequate finger length and diameter, does not have excess curvature, and upon ripening has the

desired uniform bright yellow color and sensory attributes in flavor (sweetness, acidity) and aroma. Attributes are defined by consumer preference.

**Horticultural Maturity Indices:** Commercially, bananas and plantains must be harvested while mature green and transported to destination markets where they are ripened under controlled conditions (bananas), and controlled or natural conditions (plantains). Fruits ripened on the plant often split and have poor texture. Harvest time represents a compromise between leaving the fruit on the plant long enough to maximize yield, but harvesting it soon enough so that sufficient green life remains to market fruit with acceptable quality. The stage of maturity for harvesting the fruit depends on the market for which is intended and is determined in terms of the marketable life required. Plantains tend to mature more prematurely than bananas when harvested at the same age. One very useful criteria for harvesting fruit that is used commercially is age of the bunch after emergence from the pseudostem (emergence can be defined as the day on which the first complete hand of fruit is visible). Because bananas are growing rapidly when harvested, fruit size (finger diameter, and length), and finger fullness (angularity) are suitable measures of harvest maturity. At a given age, the maturity of hands in a stem varies, those hands at the proximal end of the stem being more mature than those at the distal end. An estimate of maturity of the entire stem is then assessed using the second hand from the proximal end. It is usual to measure length/diameter (caliper grade or calibration) of the middle finger on outer whorls of the second hand on the stem before running fruit through packing plant processes.

**Grades, Sizes and Packaging:** Minimum acceptable size (length and diameter) grade standards for export markets vary depending on banana and plantain cultivar and market specifications. Hands, clusters, or single fingers not meeting these fresh market grades are used for processing products or discarded. Bananas are packed in corrugated fiberboard boxes as whole hands, clusters or individual fingers holding an average weight, for premium fruit, between 13 and 18 kg (28 to 40 lb) depending on market preference. Plantains are packed as individual fingers in 18 kg boxes. Most exporters use polyethylene film liners and paper pads to reduce moisture loss and provide protection to fruit from physical damage during handling and transport.

-Retail Outlet Display Considerations: Fruit should be displayed at retail in non-refrigerated areas in the produce section. Existing refrigerated shelf space in supermarkets normally is below the minimum safe temperature for bananas and plantains and chilling injury can still occur in ripe fruit. Displaying surfaces should be cushioned in order to avoid physical damage to the fruit.

-Chilling Sensitivity: Chilling injury is an important disorder of bananas and plantains. Both green and ripe fruit are susceptible, with green fruit being slightly more sensitive than ripe fruit. Chilling injury results from exposing fruit to temperatures below about 13 °C (56 °F) for a few hours to a few days, depending on cultivar, maturity, condition of the fruit, temperature, and duration of exposure. Chilling injury is mainly a peel disorder. Symptoms include sub-epidermal discoloration visible as brown to black streaks in a longitudinal cut, a dull or grayish (smokey) cast on ripe fruit, failure to ripen, and in severe cases the peel turns dark brown or black, and even the flesh can turn brown and develop an off taste. Chilled fruit are more sensitive to mechanical injury. Ripe fruit, if chilled, turn dull brown when later exposed to higher temperatures and are very susceptible to handling marks; the slightest pressure causes discoloration. Inflicted chill in green or ripe fruit may not become apparent until 18 to 24 h after actual damage has occurred.

-Controlled Ripening: Mature bananas left to ripen naturally will eventually soften but the change in color will not be uniform and the peel will be dull, pale yellow and unattractive. In order for the fruit to attain a bright yellow peel color, a firm pulp texture, and good flavor, bananas are ripened by releasing ethylene into a sealed chamber or room and at controlled temperature and RH. Plantains are being ripened by this controlled method in most markets but in some they still rely on natural ripening. Immediately after harvest bananas do not respond to ethylene treatment or, in the best scenario will initiate ripening but will never attain the

characteristic bright yellow coloration. One main reason for controlled ripening is to provide retailers and wholesalers with fruit at a stage of ripeness desired by consumers. Optimum RH levels during ripening are 90 to 95% (after coloring is underway RH should be reduced to 85% to prevent peel splitting). High RH requirements for proper ripening can be attained when the fruit is being packed in partially-sealed polyethylene liners. Exposure of ripe bananas or plantains to temperatures higher than those in the ripening range hastens softening and decay, weakens the neck, can cause splitting of the peel, and may cause poor color development.

-Physiological Disorders: A condition known as 'maturity bronzing' or 'maturity stain' has been observed in Australia and Central America at certain times during the year, 20 to 30 days before harvest. The fruit is unacceptable for market although eating quality is unaffected. This disorder has been associated with water deficits at bunch emergence during rapid fruit growth under very humid and hot conditions. If bananas and plantains are exposed to temperatures above 30 to 35 °C, ripening can be irreversibly inhibited (high temperature injury).

-Postharvest Pathology: The main postharvest pathological diseases of bananas and plantains are crown rot, a disease complex caused by several fungi (*Colletotrichum musae*, *Fusarium semitectum*, *Fusarium pallidoroeseum*, *Lasiodyplodia theobromae*, *Botryodyplodia theobromae*, *Ceratocystis paradoxa*, *Verticillium* sp., *Acremonium* sp., *Curvularia* sp.) and anthracnose (*Colletotrichum musae*). Anthracnose is a latent infection that occurs in the plantation, although it can appear on green fruit is more apparent in ripening fruit as numerous small dark circular spots. Crown rot organisms normally enter after harvest, usually as a result of mechanical injury to the fruit. Other diseases that from time to time become important locally include: stem end rot (*Lasiodyplodia theobromae* / *Thielaviopsis paradoxa*) where the invaded flesh becomes brown, soft and water-soaked; cigar end rot (*Verticillium theobromae* / *Trachysphaera fructigena*) where the rotted tip of the finger is dry and appears similar to the ash of a cigar. Sigatoka disease of bananas is caused by *Mycosphaerella* sp. and has been reported in most banana/plantain producing countries. The potential of this fungal disease is such that a flourishing banana industry can be destroyed within a few years. Fruit symptoms include premature ripening, buff-colored pulp, and increased susceptibility to chilling injury. Preventive and control measures to reduce decay incidence begin with strict sanitation in plantation and packing plant, postharvest treatment with systemic fungicides, minimize mechanical damage during handling, prompt cooling of fruit to lowest safe temperature, and expedite transport to final destination.

-Suitability as Fresh-Cut Product: Bananas and plantains are not good candidates for fresh-cut processing because of their very high oxidation and browning potential. Special Considerations: Mechanical damage in bananas and plantains take several forms that vary in importance depending upon the perceptions of consumers. Banana peel is very sensitive to mechanical damage. Requirements for plantains in the export market are less severe.

#### **Resources:**

- #1- Tropical Legumes: Resources for the Future
- #2- The Handbook of Industrial Crops
- #3- Neem: A Tree for Solving Global Problems
- #4- Guidelines for Seed Exchange and Plant Production in Tropical Crops
- #5- Technologies for Sustainable Agriculture in the Tropics
- #6- Replenishing Soil Fertility in Africa
- #7- Soil and Water Conservation for Productivity and Environmental Protection
- #8- Working with Farmers for Better Land Husbandry
- #9- Agriculture and Environment: Bridging Food Production and Environmental Protection in Developing Countries
- #10- Principles of Tropical Agronomy
- #11- Tree Crops: A Permanent Agriculture
- #12- Vetiver Grass: A Thin Green Line Against Erosion

**Attachment #3, Republic of Congo Plant List is an EXCEL file: Plants.xls**

## REPUBLIC OF CONGO PLANT LIST, ATTACHMENT #3

### I- STARCH PLANTS:

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1	<i>Igname</i>	<i>Yam</i>	<i>Dioscoreaceae</i>	<i>Dioscorea spp</i>
2	<i>Mais</i>	<i>Maize, corn</i>	<i>Gramineae</i>	<i>Zea mays</i>
3	<i>Manioc</i>	<i>Cassava</i>	<i>Euphorbiaceae</i>	<i>Manihot utilissima</i> <i>Manihot esculenta</i>
4	<i>Patate douce</i>	<i>Sweet potato</i>	<i>Convolvulaceae</i>	<i>Ipomea batata</i>
5	<i>pomme de terre</i>	<i>Potato</i>	<i>Solanaceae</i>	<i>Solanum tuberosum</i>
6	<i>Riz</i>	<i>Rice</i>	<i>Gramineae</i>	<i>Oryza sativa</i>

### II- SPICE PLANTS:

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1	<i>Gingembre</i>	<i>Ginger</i>	<i>Zingiberaceae</i>	<i>Zingiber officinale</i>
2	<i>Piment</i>	<i>Chili, red pepper</i>	<i>Solanaceae</i>	<i>Capsicum frutescens</i>

### III- FRUIT PLANTS:

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1	<i>Oranger</i>	<i>Orange</i>	<i>Rutaceae</i>	<i>Citrus sinensis</i>
2	<i>Bigaradier</i>	<i>Sour orange</i> <i>Bitter oranger</i>	<i>Rutaceae</i> <i>Rutaceae</i>	<i>Citrus aurantium</i>
3	<i>Pamplemoussier</i>	<i>Pummelo shaddock</i>	<i>Rutaceae</i>	<i>Citrus grandis</i>
4	<i>Mandarinier</i>	<i>Madarin</i>	<i>Rutaceae</i>	<i>Citrus reticulata</i>
5	<i>Citronnier</i>	<i>Lemon</i>	<i>Rutaceae</i>	<i>Citrus limon</i>
6	<i>Ananas</i>	<i>Pineapple</i>	<i>Bromeliaceae</i>	<i>Ananas spp</i>
7	<i>Avocatier</i>	<i>Avocado</i>	<i>Lauraceae</i>	<i>Persea americana</i>
8	<i>Safoutier</i>			<i>dacryodes edulis</i>
9	<i>Bananier</i>	<i>Banana plantain</i>	<i>Musaceae</i>	<i>Musa spp</i>
10	<i>Litchi</i>	<i>Lychee</i>	<i>Sapindaceae</i>	<i>Nephelium litchi</i>
11	<i>Manguier</i>	<i>Mango</i>	<i>Anacardiaceae</i>	<i>Mangifera indica</i>
12	<i>Papayer</i>	<i>Papaw tree,</i> <i>Papaya</i>	<i>Caricaceae</i>	<i>Carica papaya</i>
13	<i>Goyavier</i>	<i>Guava Tree</i>	<i>Myrtaceae</i>	
14	<i>Corrosolier</i>	<i>Soursop</i>		<i>Annona muricata</i>

### IV - VEGETABLE PLANTS( CARDOO)

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1	<i>Amarante</i>	<i>Amaranth</i>	<i>Amaranthaceae</i>	<i>Amaranthus hybridus</i>
2	<i>Aubergine</i>	<i>Egg plant</i>	<i>Solanaceae</i>	<i>Solanum melongena</i>
3	<i>Epinard</i>	<i>Spinach</i>		<i>Spinacia oleracea</i>
4	<i>Oseille de guinée</i>	<i>Roselle</i>	<i>Malvaceae</i>	<i>Hibiscus sabdarifa</i>
5	<i>Baselle</i>	<i>Sweet basil</i>	<i>Basellaceae</i>	<i>Basella alba</i>
6	<i>Choux</i>	<i>Cabbage</i>	<i>Crucifere</i>	<i>Brassica oleracea</i>
7	<i>Gombo</i>	<i>Okra</i>	<i>Malvaceae</i>	<i>Hibiscus, abelmoschus esculentus</i>
8	<i>Laitue</i>	<i>lettuce</i>	<i>Composeae</i>	<i>Lactuca sativa</i>

9	Niébé	Cow pea	Leguminoseae	Vigna spp
10	Oignon	Onion	Liliaceae	Allium cepa
11	Poireau	Leek	Liliaceae	Allium porrum
12	Poivron	Sweet pepper	Solanaceae	Capsicum annum

13	Tomate	Tomato	Solanaceae	<i>Lycopersicum esculentum</i>
14	Concombre	Cucumber	Cucurbitaceae	<i>Cucumis sativus</i>
15	Pastèque	Watermelon	Cucurbitaceae	<i>Citrullus lanatus</i>
16	Courges	Vegetable marrow, gourd	Cucurbitaceae	
17	Carotte	Carrot		<i>Daucus carota</i>
19	Endive	Chicory		
20	Taro	Cocoyam	Araceae	<i>Colocasia spp</i>
21	Haricot	Bean	Leguminoseae	<i>Phaseolus vulgaris</i>

## V - OIL PLANTS

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1	Arachide	Groundnut Peanut	Papilionaceae	<i>Arachis Hypogea</i>
2	Cocotier	Coconut	Palmaceae	<i>Cocos nucifera</i>
3	Palmier à huile	Oil palm	Palmaceae	<i>Elaeis guineensis</i>
4	Sésame	Benniseed	Pedaliaceae	<i>sesanum spp</i>
5	Soja	Soy bean	Papilionaceae	<i>Glycine max</i>

## VI - PARFUM PLANTS

1	Citronnelle	Citronnellagrass	Gramineae	<i>Cymbopogon nardus</i>
2	Eucalyptus	Blue gum; lemon Scented gum	Myrtaceae	<i>Eucalyptus globulus,</i> <i>Eucalyptus citriodora</i>

## VII - SUGAR PLANT!

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1	Canne à sucre	Sugar cane	Gramineae	<i>saccharum spp</i>

## VIII - STIMULANT PLANT!

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1	Cacaoyer	Cocoa	Sterculiaceae	<i>Theobroma cacao</i>
2	Cafeier	Coffee	Rubiaceae	<i>Coffea spp</i>
3	Colatier	Kola	Sterculiaceae	<i>Cola acuminata</i>
4	Tabac	Tobacco	Solanaceae	<i>Cola nitida</i> <i>Nicotiana spp</i>

## IX - TEXTILE/ COTTON PLANT

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1	Cotonnier	Cotton	Malvaceae	<i>Gossypium spp</i>

## X - MEDICAL PLANTS

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1		<i>Eucalyptus</i> (English: Alpine Ash (Leaves to cure cough))		
2		<i>Auinaueliba</i> (Leaves to cure malaria)		
3		<i>Lantana camara</i> (shrub)(Leaves to cure Cough)		
4		<i>Chromonela odoratum</i> (Wounds)		

5 | Desmodium spp (to cure eyes)

Quinquéliba, the lantana and chromonela are indigenous plants but can be obtained by seeds(Quinquéliba) or by cutting( for lantana and chromonela)

### XI - LOCAL NATURAL FOOD PLANTS

N°	FRENCH NAME	ENGLISH NAME	FAMILY	SCIENTIFIC NAME
1	Malombo			<i>Landolphia spp</i>
2	Tondolo			<i>Afromomum africanum</i>
3	Minguengui			<i>pseudo spondias</i>
4	Bamboutou			<i>Spodias mambin</i>
5	Mtsui-téké			<i>Grewia spp</i>
6	Pava			<i>Treculia spp</i>

### XII - SPECIES SHOWING SOIL ACIDITY

1	Fougere (fern)			<i>Filicaria spp</i>
2	Nianga Tsédo			<i>Imperata cylindrica</i>
3	Carex			<i>Cyperaceae family</i>

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